

1                    HIGH FREQUENCY RF INTERCONNECT FOR  
2                    SEMICONDUCTOR AUTOMATIC TEST EQUIPMENT

3                    BACKGROUND OF THE INVENTION

4                    The present invention relates to automatic test equipment  
5 and, in particular, to a radio frequency interconnection system  
6 for use in connecting a device under test to a measurement  
7 device.

8                    Semiconductor devices are often tested by test equipment  
9 that includes a probe card that is configured with fine probes  
10 that make electrical contact with desired points on the  
11 semiconductor device. A differently configured probe card can be  
12 used for different semiconductor devices. The probe card is then  
13 mated with a test head that is typically able to mate with the  
14 differently configured probe cards in a uniform manner. The test  
15 head either includes or is connected to the measurement devices  
16 required to perform the desired tests on the semiconductor  
17 devices.

18                   When a different semiconductor device is to be tested, it is  
19 desirable to "drop-in" the appropriate probe card into the test  
20 equipment and connect the test head to the probe card.

21                   For non-RF testing, various satisfactory ways of connecting  
22 the probe card to the test head have been developed. U.S. Patent  
23 No. 5,808,475 shows a probe card and test head connection scheme  
24 and is incorporated herein by reference. These techniques have  
25 proven unsatisfactory for RF testing because of the tendency for  
26 the RF energy to radiate. For RF testing, coaxial cables and  
27 connectors are desirable for controlling RF radiation. However,  
28 existing RF connection systems are not suitable for the quick and  
29 simple connection desired for the use of "drop-in" probe cards.

## SUMMARY OF THE INVENTION

A RF test interconnection system for connecting a measurement device to a device under test includes, a probe card having a probe extending from a first side of the card for making electrical contact with the device under test and a coaxial connector extending from a second side of the card, a test head having a test head coaxial connector that will mate with the probe card coaxial connector when the probe card and the test head are urged together, and a de-mating device attached to either the probe card or the test head for urging the probe card and the test head apart by applying a separating force therebetween. The probe card and the test card coaxial connectors are electrically connected when the test head and the probe card are urged together by a connection force and electrically disconnected when the connection force is removed.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a semiconductor tester according to the invention.

FIG. 2 is a perspective view of a probe card and a test head according to the invention.

FIG. 3 is a perspective view of a portion of a probe card according to the invention.

FIG. 4 is a bottom view of the mating portion of a test head according to the invention.

FIG. 5 is a cross section view along the line 4-4 of FIG. 4 wherein the test head and the probe card are starting to mate.

FIG. 6 is a cross section along the line 4-4 of FIG. 4 wherein the test head and the probe card are fully mated.

1                    DESCRIPTION OF THE PREFERRED EMBODIMENTS

2            Referring to FIG. 1, a semiconductor device tester 10 for  
3 performing tests on semiconductor device includes a measurement  
4 device 12, a test head 14 and a probe card 16. The measurement  
5 device 10 performs electrical measurements on the device under  
6 test (DUT) 90.

7            In operation, the tester 10 is configured such that the DUT  
8 90 is placed under the probe card 16 which contains fine  
9 electrical probes that contact points of interest on the DUT 90.  
10 Different probe cards may be conveniently configured to have  
11 probes that are arranged for different DUTs. The bottom portion  
12 of the probe card 16 has a selection and pattern of probes. The  
13 top portion of the probe card 16 has connectors that mate with  
14 the test head 14 in a more standard arrangement than that of the  
15 probes. The measurement device 12 is either contained within the  
16 test head 16 itself or is electrically connected thereto.

17           To allow for the rapid, trouble-free, reconfiguration of the  
18 tester 10 for the testing of a different DUT or to otherwise use  
19 a different probe card 16, it has been found to be desirable to  
20 be able to retract the test head 12 from the probe card 16 and to  
21 lift the probe card 16 out of an unshown carrier. A new probe  
22 card 16 is "dropped" into the tester 10 and the test head 12  
23 again mated with the probe card 16.

24           Referring to FIG. 2, when RF (e.g., frequencies up to 60  
25 GHz) measurements are desired, a test head 14 and a probe card 16  
26 may be used that include coaxial connectors 18, 20. The test  
27 head 14 and the probe card 16 are shown without their support  
28 structures for ease of understanding. It also should be  
29 understood that one or more additional test heads may also be  
30 arranged in a radial blade-like fashion above the probe card.  
31 These test heads may be referred to collectively as a test head

1 as well, as they are typically all mounted to a common support  
2 structure. The central aperture 22 in the probe card 16 contains  
3 the fine probes (not visible) for making contact with the DUT 90.

4 Referring to FIG. 3, a portion of the probe card 16 that  
5 mates with the test head 12 includes the coaxial connectors 18,  
6 20 and alignment apertures 24, 26. The apertures 24, 26 may  
7 advantageously be tapered to assist in aligning the test head 14  
8 to the probe card 16 as more fully explained below.

9 Referring to FIG. 4, the bottom surface of the test head 16  
10 that mates with the probe card 16 includes the coaxial connectors  
11 28, 30, the alignment pins 32, 34 and the de-mating devices 36,  
12 38. The alignment pins 32, 34 may be advantageously tapered to  
13 assist in aligning the test head 14 with the probe card 16.

14 In the preferred embodiment, the de-mating devices 36, 38  
15 are spring-loaded plungers, but other devices could be used such  
16 as electrical solenoids, cams, fluid-powered actuators and the  
17 like.

18 Referring to FIG 5, the mating portions of the test head 14  
19 and the probe card 16 are shown in cross section along the line  
20 4-4 of FIG. 4 as the portions start to mate. The alignment pin  
21 32 has entered the alignment aperture 26 and the alignment pin 34  
22 has entered the alignment aperture 24 (not visible).

23 The coaxial connector 20 has inner conductive female  
24 receptacle 40, an insulating sleeve 42 and an outer conductive  
25 female barrel 44. The barrel 44 may advantageously include a  
26 tapered mouth 46 to aid in alignment during mating.

27 The coaxial connector 28 has a male conductive center pin  
28 48, an insulating sleeve 50 and an outer conductive male barrel  
29 52. The pin 48 may advantageously be pointed and tip of the  
30 barrel 52 tapered to aid in alignment. The pin 48, sleeve 50 and  
31 barrel 52 form a unit 54 that is retained within an enclosure 56.  
32 The unit 54 is biased towards the probe card 16 by a compression  
33 member such as the spring 58 within the enclosure 56.

1 Referring to FIG. 6, the mating portion of the test head 14  
2 and the probe card 16 are shown in cross section along the line  
3 4-4 of FIG. 4 when the portions are fully mated. This mating is  
4 produced by an unshown mechanism that urges the test head 14 and  
5 the probe card 16 together to produce a functioning tester 10.

6 The connector 28 is fully seated in the connector 20 and the  
7 unit 54 has been displaced against the compressive force of the  
8 spring 58 to provide a firm, constant, connection. The pin 48  
9 has slid into the receptacle 40 and the barrel 52 has slid into  
10 and seated in the barrel 44.

11 In addition, the plunger 60 of the de-mating device 38 has  
12 been forced into the device 38 by pressure against the probe card  
13 16. Similarly, the unshown plunger of the de-mating device 36  
14 has been forced into the device 36.

15 The sliding mating of the connectors 18, 20, 28, 30, as well  
16 as to a lesser degree, the pins 32, 34 and apertures 24, 26  
17 provide substantial resistance to the de-mating of the test head  
18 14 from the probe card 16. The de-mating devices 36, 38 overcome  
19 this resistance when the test head 14 is lifted up from the  
20 tester 10. Without the devices 36, 38, the probe card 16 would  
21 either stay attached to the test head 14, or worse, fall off  
22 suddenly, causing damage.

23 The present invention provides the ability to use "drop-in"  
24 probe cards for RF measurements. There is no need to manually  
25 make RF connections with each probe card change. The probe card  
26 is positively released merely by retracting the test head,  
27 without danger of the probe card "sticking" to the test head.

28 It should be noted that, in general, male and female  
29 components and the de-mating devices can be reversed with respect  
30 to their locations on the test head and the probe card.

31 It should be evident that this disclosure is by way of  
32 example and that various changes may be made by adding, modifying  
33 or eliminating details without departing from the fair scope of

1 the teaching contained in this disclosure. The invention is  
2 therefore not limited to particular details of this disclosure  
3 except to the extent that the following claims are necessarily so  
4 limited.